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MULCH
as a management system
for GRAPES

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MULCH AS A SOIL MANAGEMENT SYSTEM FOR GRAPES

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For many years intensive cultivation has been the rule in vineyard soil management. The practice usually included deep plowing at least once each season and several cultivations with the grape hoe and disc. Unless an overwintering cover crop was sown, the vineyard soil was essentially bare the year around. The detrimental effects of severe cultivation have been pointed out by numerous workers (1, 3, 5, 6, and 7). Wander (9) attributed the decline in production of grapes in Ohio in large part to the destruction of a favorable surface soil aggregation and a serious loss of organic matter and total nitrogen by long continued, intensive tillage practices. Shaulis (6) cautions regarding the serious damage that may be done to grape roots by deep discing, grape hoeing, or plowing. He further observes that cultivation to control weeds is essential and probably the only reason to cultivate a vineyard. Fortunately, there is a trend toward less frequent and less severe vineyard cultivation, an encouragement in the use of overwintering cover crops, and an increasing interest in the addition of organic matter in the form of hay, straw, manure, and grape pumice. Although these practices help to counteract some of the disadvantages of a cultivation system of soil management, they do not provide a complete solution to the problems of erosion control, weed control, and grape vine root injury from tillage implements.

The benefits of a permanent mulch system of soil management for certain of the tree fruits has long been recognized. Its use with the grape has not been reported. The purpose of this paper is to present data on pruning weights, number of buds left at pruning, yields, soluble solids and acid content of the fruit, and nitrogen and mineral content of the leaf petioles of Concord grapes grown under the straw mulch and the cultivation plus cover crop systems of soil management.

METHODS

The experimental vineyard was located on a Wooster silt loam soil at Wooster, Ohio on a level site. Plants were set in the spring of 1944 with vines nine feet apart in rows nine feet apart. The permanent

trellis was in place by the beginning of the second growing season. It consisted of a two-wire trellis with the top wire at 5½ feet above ground level. The vines were trained to the four-cane Kniffen system. By the spring of 1948 it became apparent that the vigor of the vines in certain plots was such that additional trellis was required. At that time the trellis was raised to permit the use of three wires with the top wire at 6 feet above ground level. The vines have since been trained to the six-cane Kniffen system in those cases where there was sufficient vigor to support that number of canes.

Differential treatments were begun in 1945. Two rows, each consisting of 29 vines of the Concord variety, were utilized in the test. These rows were separated by a guard row. One row was mulched with wheat straw at the rate of 10 tons per acre. The entire aisle area on either side of this row was covered with straw. The mulch has since been replenished annually to maintain a layer of straw of from 10-12 inches in depth. From 1945 to 1953 the equivalent of about 50 tons per acre of straw has been applied. The second row was maintained under the cultivation plus cover crop system of soil management during the same period. Rye was sown in late August of each year and disced down in the early spring. Cultivation for the remainder of the season was accomplished by light discing of the row middles and by hand hoeing under the trellis.

Each of these two rows was further treated with different rates of application of nitrogen fertilizer. For this purpose each row was divided into six four-vine subplots separated by a single buffer vine. Three treatments were employed. These consisted of annual 0, 40, and 80 lb. per acre applications of actual nitrogen. Thus, each treatment occurred twice under each system of soil management. The fertilizer applications were made in early April each year.

From the time the vineyard was established through 1951 all vines were pruned in a manner similar to grower practice with respect to the number of buds left per vine. In 1952 and 1953 all vines were balanced pruned according to New York recommendations for the Concord variety. This consisted of leaving 30 buds for the first pound of one-year prunings and 10 additional buds for each additional pound of one-year prunings.

Yield data in terms of number of clusters and pounds of fruit per vine were obtained from 1947 through 1953. Composite samples of fruit were taken at harvest time in 1952 and 1953 from each four-vine plot. Soluble solids were determined on the expressed juice using an

Abbe refractometer. Titratable acids were determined by diluting a 10 ml. aliquot of the expressed juice to 100 ml. with distilled water and titrating to pH 8.0 with 0.1 N NaOH. These data were utilized to calculate ratios between the soluble solids and acids content of the fruit. The percentage of acids is expressed as tartaric acid.

Leaf samples were taken on July 17, 1952 and on July 10, 1953 for chemical analyses. The blades and petioles were separated and only the petiole data are presented herein. The leaf chosen in sampling was the first mature leaf from the apical end of a fruiting shoot. Twelve such leaves were taken from each vine and composited to make a 48 leaf sample from each four-vine plot. Total nitrogen was determined by the official Kjeldahl Gunning method (2). Total phosphorus and manganese were determined by the semi-micro methods of Peech (4). Total calcium, magnesium, and potassium were determined flame photometrically using the quartz spectrophotometer with flame attachment and photomultiplier. All results are expressed on the dry weight basis.

RESULTS

Pruning Weights: The data for pruning weights are presented in Table 1. Since balanced pruning was not practiced prior to 1952, the average weights shown in this table represent only the years 1952 and 1953. It is readily apparent from these data that the mulched vines were much more vigorous than the cultivated vines. The average pruning weight from mulched vines was 4.74 pounds per vine and from the cultivated vines was only 1.47 pounds. This difference was highly significant. In contrast to the large differences occurring between management systems the differences between different rates of nitrogen fertilizer application were not significant. The reason for this is principally because the effect of nitrogen fertilization was different under the two soil management systems. As is shown in Table 1, under cultivation as the nitrogen application increased from 0 to 40 and finally to 80 lbs., the pruning weights increased from 1.00 to 1.26 and to 2.15 pounds, respectively. Under mulch, however, pruning weights decreased as the nitrogen supply increased but the differences in this instance were not statistically significant. These data illustrate the need for nitrogen fertilizers in the cultivated plots but show that with the high state of vigor obtained after the mulch was well established no benefit was obtained from the use of nitrogen.

TABLE 1.—The effect of soil management system and differential nitrogen fertilization on the weight of one-year old wood removed from balanced pruned Concord grape vines in 1952 and 1953. The data are expressed as the average pounds of prunings removed per vine per year.

Nitrogen treatment	Soil Management System		Nitrogen treatment means
	Cultivation	Mulch	
No nitrogen	1.00	5.06	3.03
40 lbs. N/Acre/yr.	1.26	4.67	2.97
80 lbs. N/Acre/yr.	2.15	4.50	3.33
Soil management means	**1.47**	**4.74**	

L.S.D.	Soil Management Means	5 %	0.51
		1 %	0.68
L.S.D.	Nitrogen Treatment Means	5 %	N.S.
		1 %	N.S.
L.S.D.	Soil Management × Nitrogen Means	5 %	0.88
		1 %	1.17

Buds Left After Pruning: The differences in number of buds left after balanced pruning serve as another indication of vine vigor as influenced by treatment. Since the bud number was determined by the pruning weight these data should reflect the same trends as those on pruning weights. Examination of the data in Table 2 reveals this to be the case. The mulched vines were of sufficient vigor to support many more buds than were the cultivated vines. The difference in favor of the mulch system of management was highly significant. The average number of buds on mulched vines was 62 which was significantly more than the 32 buds the cultivated vines were capable of supporting.

As in the case of pruning weights, there was no significant difference in average number of buds per vine between the different nitrogen treatments. Again this was because under cultivation the number of buds per vine increased as the nitrogen application increased, while under mulch the number of buds per vine decreased as the nitrogen application increased. For cultivation these differences were significant at the 1 percent level between the ON and 8ON treatments and between the 40N and 8ON treatments. For mulch the difference was significant at the 5 percent level between the ON and the 8ON treatment.

TABLE 2.—The effect of soil management system and differential nitrogen fertilization on the number of buds left on balanced pruned Concord grape vines in 1952 and 1953. The data are expressed as the average number of buds left per vine per year.

Nitrogen treatment	Soil Management System		Nitrogen treatment means
	Cultivation	Mulch	
No nitrogen	27	67	47
40 lbs. N/Acre/yr.	29	62	45
80 lbs. N/Acre/yr.	41	58	49
Soil management means	**32**	**62**	

L.S.D.	Soil Management Means	5%	4.7
		1%	6.3
L.S.D.	Nitrogen Treatment Means	5%	N.S.
		1%	N.S.
L.S.D.	Soil Management × Nitrogen Means	5%	8.2
		1%	10.9

Petiole Analyses: The petiole contents of total nitrogen, phosphorus, potassium, calcium, magnesium, and manganese in July of 1952 and 1953 are presented in Table 3. These data are presented for cultivation and mulch treatments only and include all nitrogen treatments. Each value presented in Table 3 represents the average for two composite samples obtained as described in the section on methods. Because only two such samples were used for analysis, these data were not treated statistically. The differences appear to be of sufficient magnitude, however, to justify certain conclusions. Nitrogen was about 30 percent higher in the leaf petioles of the mulched vines both years. Phosphorus

TABLE 3.—The effect of soil management system on the July petiole contents of certain essential elements expressed on the dry weight basis.

Essential element	Cultivation		Mulch	
	1952	1953	1952	1953
% Nitrogen	1.01	0.93	1.39	1.28
% Phosphorus	0.147	0.125	0.213	0.248
% Potassium	1.07	1.15	4.01	3.55
% Calcium	1.12	1.21	0.92	0.73
% Magnesium	0.70	0.54	0.17	0.12
ppm Manganese	824	645	1254	1295

in the petioles of mulched vines was about 50 percent higher in 1952 and nearly 100 percent higher the following year. The potassium content of the petioles of mulched vines was three times that of cultivated vines in 1953 and nearly four times that of the cultivated vines in 1952. The petiole contents of calcium and magnesium from cultivated vines were higher than those of mulched vines during both years. The petioles of the cultivated vines contained slightly over four times as much magnesium as did those from the mulched plots. The differences in calcium content were much smaller, but were consistent for both years. Manganese was higher in the petioles of the mulched vines both years.

Certain seasonal differences are evident in addition to the differences associated with treatment. Nitrogen and magnesium were lower in 1953 under both cultural systems. Phosphorus was lower under cultivation, but higher under mulch in 1953 than in the previous year. Potassium and calcium were higher under cultivation, but lower under mulch in 1953 than in 1952. The seasonal differences in manganese were not large enough to justify comment.

Yield: For the seven-year period from 1947 through 1953 the mulched vines produced on the average 16.9 pounds of fruit per vine, Table 4. During the same period cultivated vines produced on the average 11.4 pounds per vine, Table 4. The difference in average yield in favor of

TABLE 4.—The effect of soil management system and differential nitrogen fertilization on the average yield of Concord grapes from 1947 through 1953. The data are expressed in pounds of fruit produced per vine per year.

Nitrogen treatment	Soil Management System		Nitrogen treatment means
	Cultivation	Mulch	
No nitrogen	9.6	16.4	13.0
40 lbs. N/Acre/yr.	10.1	18.5	14.3
80 lbs. N/Acre/yr.	14.4	15.7	15.1
Soil management means	**11.4**	**16.9**	. .

L.S.D.	Soil Management Means	5 %	1.31
		1 %	1.73
L.S.D.	Nitrogen Treatment Means	5 %	1.31
		1 %	N.S.
L.S.D.	Soil Management × Nitrogen Means	5 %	2.27
		1 %	2.99

the mulch system of management was significant at the 1 percent level. Considering the average yields for different nitrogen treatments, the difference between the ON and 8ON treatment was significant at the 5 percent level. As was the case with pruning weight and bud number it is evident from the data in Table 4 that differential nitrogen treatment affected yield differently under mulch and under cultivation. With the cultivation system of management, as the nitrogen supply increased the average yield also increased. The difference between ON and 80 N was significant at the 1 percent level in this case. Under the mulch system of management there was no significant difference between the ON and 40 N treatments although the yield was slightly higher with 40 pound per acre applications of nitrogen. Further increasing the nitrogen application to 80 pounds per acre, however, resulted in a significant decrease in yield under mulch.

A detailed study of the yield data for individual years (Table 5) shows that in four of the seven years as the nitrogen supply increased, yields also increased under cultivation. Under mulch in every year except 1953, the highest yield was obtained when 40 pounds per acre of actual nitrogen was applied, and in all but two years, the lowest yield was obtained when 80 pounds of nitrogen was applied. These data demonstrate the difference in yield performance to differential nitrogen treatment as it is influenced by soil management system. Apparently, in the case of a permanent mulch system a moderate application of

TABLE 5.—The effect of soil management system and differential nitrogen fertilizer application on the average yield of Concord grapes per vine per year from 1947 through 1953.

Year	Average yield—pounds per vine					
	Cultivation			Mulch		
	ON	4ON	8ON	ON	4ON	8ON
1947	1.6	0.5	1.4	4.7	9.5	4.2
1948	3.6	2.7	5.6	6.3	8.2	4.9
1949	7.9	8.9	11.8	20.0	20.1	17.0
1950	16.4	16.3	24.3	14.2	15.5	15.8
1951	11.7	11.7	19.6	22.2	28.8	28.1
1952	5.5	13.0	15.2	18.0	22.0	17.8
1953	20.4	17.9	23.0	29.3	25.1	22.2
Mean	9.6	10.1	14.4	16.4	18.5	15.7

nitrogen is necessary for the first few years until sufficient decomposition of the mulch material has taken place. Under the conditions of this experiment additions of nitrogen after six years have not been advantageous and have actually been associated with reductions in yield. Yield data obtained in 1954 and 1955 have continued to show this trend. The use of mulch material other than wheat straw might be expected to alter the length time until no benefit would be realized from the application of nitrogen.

Soluble Solids and Acids: The soluble solids content of the fruit from cultivated vines was higher both years than that from mulched vines (Table 6). In 1952 this amounted to a 2.7 percent differential in favor of the cultivation system of management. In 1953, when the soluble solids content of the fruit from both treatments was considerably lower than the previous year the cultivation treatment showed about a 1 percent advantage in solids content. The mulched vines produced fruit which contained higher percentages of acids. In 1952 this difference was rather large, the fruit from cultivated vines containing 0.6989 percent tartaric acid and that from mulched vines containing 0.7642 percent tartaric acid. The following year the differences were slight (Table 6). It should be noted that in the case of soluble solids, season played nearly as important a role as did cultural treatment. For example, the 1952 mulched plots produced fruit with a higher soluble solids content (14.2%) than did the 1953 cultivated plots (12.3%). The same was true, but to a lesser extent with titratable acids. The ratio of soluble solids to acids shows that within a given year higher ratios are obtained in the case of fruit from cultivated plots. However, the fruit of mulched vines in 1952 had a higher ratio of solids to acids than did the fruit of cultivated vines the following year. According to

TABLE 6.—The effect of soil management system on the quality of Concord grapes as expressed by percent soluble solids, percent titratable acids, and the soluble solids-acids ratio in the juice.

Quality Index	Cultivation		Mulch	
	1952	1953	1952	1953
% Soluble Solids	16.9	12.3	14.2	11.2
% Titratable Acids	0.6989	0.7642	0.7642	0.7746
Soluble Solids/Acids	24.3	16.2	18.6	14.5

present belief the best quality fruit is that with relatively high sugars and intermediate acids so as to give an intermediate value for the ratio of the two. Extremely high ratios characterize fruit with an incipid sweet taste while very low ratios characterize fruit that is too sour.

DISCUSSION

The failure of the mulched vines to produce crops commensurate with their vigor as indicated by pruning weights indicates that the formula for balanced pruning used in this test may not be the best for these mulched vines. This formula was originally devised for vines producing from 1 to 4 lbs. of one-year prunings and under the circumstances existing in the present work the necessity for leaving additional buds is at least indicated. A second factor which may have influenced productivity is the possibility of the development of a lower percentage of buds with high fruiting capacity as the result of shading and consequent reduced photosynthetic efficiency per unit of leaf area of the more vigorous vines. Possibilities for correcting these effects include the utilization of different training systems or types of trellis so as to more effectively expose the foliage to sunlight and the development of a pruning formula better suited to highly vigorous vines.

Despite this discrepancy between vine vigor and yield the mulch system appears to offer an economically profitable increase in productivity. Based on the spacing employed in this vineyard the 5.5 pound per vine increase in yield is equivalent to a 1.5 ton per acre increase in yield. Based on a $100 per ton evaluation of grapes this would mean that the mulch would pay for itself if applied at the rate of 10 tons per acre per year at a cost of $15 per ton spread in the vineyard.

Some discussion of the reasons for the benefits derived from the use of permanent mulch seems pertinent. Although no data are presented to support these points, it is generally accepted and has been shown in other work that a permanent mulch increases the infiltration of rainfall, aids in the control of erosion, adds organic matter to the soil, improves the physical condition of the soil, and increases the availability of certain essential elements. The petiole analyses presented show that nitrogen, phosphorus, potassium, and manganese were higher in the petioles of vines growing in mulch. They also showed reduced contents of calcium and magnesium. The relatively high levels of nitrogen and potassium in particular are believed in large part responsible for increased vine vigor and yield.

The magnesium concentrations of the mulched vines reported in Table 3 are considerably lower than that which is considered critical for other fruit crops. It should be noted, however, that these data are for petiole analyses only while the magnesium content of foliage for other fruit crops is normally determined on the entire leaf. Separate analysis of the blade portion of these samples showed that while the petioles contained from 0.12 to 0.17 percent magnesium, the blades contained more than 0.20 percent magnesium. Furthermore, in the mulched vines with high levels of potassium in the petioles, the leaf blades were always found to contain higher percentages of magnesium than the leaf petioles, while in the cultivated vines with relatively low levels of potassium in the petioles, the leaf blades were found to contain lower percentages of magnesium than did leaf petioles. These data show clearly that the distribution of magnesium between leaf blade and leaf petiole tissue is closely associated with the level of potassium in the plant. While leaf petioles may be the best tissue to use in estimating potassium status as reported by Ulrich (8), the leaf blade tissue is probably the best tissue to utilize in estimating the magnesium status of the grape.

The reduction in soluble solids content of the fruit as a result of mulch is believed primarily a matter of delay in maturity since the grapes from both cultivated and mulched plots were harvested at the same date. Because the sugar content of grapes is known to increase as long as the foliage remains functional, it is thought that this apparent disadvantage can be overcome in the future by permitting a longer time to mature.

In this study, the cultivated plots were hand hoed to avoid possible mechanical injury to the vines often found in vineyards where the grape hoe is used. The differences obtained under the two systems of management in this work may be minimized because of this fact, and in grower vineyards unless chemical weed control is practiced, differences between the two systems might be larger than those obtained in this work.

SUMMARY

Concord grapes were grown for nine years under permanent straw mulch and cultivation plus cover crop systems of soil management with different rates of nitrogen fertilizer application. The vigor of the vines as evidenced by pruning weights in 1952 and 1953 was significantly higher under the mulch system of management. Mulched vines produced on the average 16.9 lbs. of fruit per vine per year as compared with 11.4 lbs. per vine per year from the cultivated vines. The petiole concentrations of nitrogen, phosphorus, potassium, and manganese were higher while calcium and magnesium were lower under the mulch system of management. Highest total yields under cultivation occurred when 80 lbs. per acre of actual nitrogen was applied each year. With mulch the highest total yield for the period 1947 through 1953 occurred where 40 lbs. actual nitrogen per acre per year was applied. It should be noted, however, that in 1953 highest yields with mulch occurred when no nitrogen was applied and this has continued to be the case in 1954 and 1955.

The use of mulch resulted in the production of fruit containing lower soluble solids and higher acids than did cultivation. The influence of season on these constituents was nearly as great as was the influence of soil management system. The reduction in soluble solids under mulch is believed to be the result of delayed maturity and might be overcome by permitting a longer ripening period.

During the first several years while a mulch is being established, applications of 40 pounds of actual nitrogen per acre per year are recommended. With the rate and kind of mulch used in this study such applications of nitrogen were beneficial for the first six years of production. This period would vary with different kinds of mulch material. Sawdust, for example, would decompose less readily and might require prolonged applications of nitrogen, whereas more rapidly decomposing materials which were relatively high in nitrogen might require less than six years of nitrogen fertilizer application.

The use of a permanent mulch system of management for Concord grapes is believed to be economically sound and to possess certain advantages not obtainable under the conventional cultivation plus cover crop soil management system.

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